SCIENCE LIBRARY

JAN 13 1927

Technical Paper 399

DEPARTMENT OF COMMERCE
HERBERT HOOVER, SECRETARY
BUREAU OF MINES
SCOTT TURNER, DIRECTOR

RECOVERY OF MOLYBDITE FROM THE ORE

By

H. A. DOERNER

PRICE 5 CENTS

Sold only by the Superintendent of Documents, Government Printing Office
Washington, D. C.

WASHINGTON
GOVERNMENT PRINTING OFFICE
1926

Generated on 2024-10-06 18:22 GMT / https://hdl.handle.net/2027/mdp.39015006902764
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

Digitized by Google

Original from
UNIVERSITY OF MICHIGAN

CONTENTS

	Page
Introduction	1
Use of molybdenum	1
Molybdenum minerals	2
Possible methods of recovering molybdite	3
Flotation	3
Gravity concentration	3
Dielectric concentration	4
Leaching	4
Distillation with chlorine	10
Summary	12

ILLUSTRATIONS

Figure	
1. Diagram of process for recovering a pure molybdic acid from a sodium carbonate leach	6
2. Diagram of process for recovering a pure molybdic acid from a sulphuric acid leach	8
3. Apparatus used in laboratory tests	10

Generated on 2024-10-06 18:24 GMT / https://hdl.handle.net/2027/mdp.39015006902764
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF MICHIGAN

RECOVERY OF MOLYBDITE FROM THE ORE

By H. A. Doerner

INTRODUCTION

One of the duties of the Bureau of Mines is to seek to increase efficiency in the mining, treatment, and utilization of minerals. In 1914 the bureau began an investigation of the molybdenum resources of this country with the purpose of aiding the establishment of a molybdenum industry. The results of that investigation were published in Bulletin 111. This paper discusses the utilization of molybdite.

USE OF MOLYBDENUM

A rapidly increasing amount of molybdenum is being used in the manufacture of alloy steels, to which, in conjunction with other metals, molybdenum imparts many desirable properties. Much smaller amounts of molybdenum are used in metallic form for electrical equipment, in nonferrous alloys, and in chemical reagents, dyes, and various other chemical products.

Until recently molybdenum was added to steel in the form of ferromolybdenum. At present, however, most of the molybdenum used in steel is added in the form of calcium molybdate; reduction and combination as alloy result from the contact of the molybdate with the molten steel. This change marks an important economy in the production of molybdenum alloys for the following reasons: (1) Reduction to ferromolybdenum involves considerable loss of metal in the slag, whereas calcium molybdate may be made without appreciable loss. (2) To convert a concentrate to calcium molybdate costs much less than to reduce it to ferromolybdenum. (3) Detrimental impurities are easily eliminated during the process of making calcium molybdate, thus making a wider variety of ores available as a source of molybdenum.

Ferromolybdenum usually contains 50 to 60 per cent Mo; 2 per cent carbon is the maximum for one grade and 0.5 for another. Calcium molybdate is sold containing about 42 per cent Mo. The presence of appreciable amounts of phosphorus, sulphur, or any easily reducible metal is not usually tolerated in either ferromolybdenum or calcium molybdate.

100208°—26——1

Generated on 2024-10-06 18:15 GMT / https://hdl.handle.net/2027/mdp.39015006902764
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF MICHIGAN

MOLYBDENUM MINERALS

According to Hess,[1] "Molybdenite is by far the most widely distributed molybdenum mineral, occurs in the greatest quantity in individual deposits, and is the molybdenum mineral in most of the ore produced. * * * The minerals accompanying the molybdenite are those usually found in tactites * * * namely garnet, epidote, hornblende, pyroxenes, scheelite, sulphides of iron, copper and zinc, zeolites and others."

Molybdite, a hydrated ferric molybdate, generally occurs in molybdenite ores as an oxidation product. By flotation, the present method of concentration, a high recovery of the molybdenite is usually obtained, but the molybdite or oxidized portion of the ore is lost in the tailing. Virtually all the known deposits of molybdenite contain considerable molybdite, the recovery of which presents an important problem in the prevention of an economic waste.

The largest developed source of molybdenum is at Climax, Colo. It consists of an immense body of brecciated porphyry and granitic rocks of several kinds in which molybdenite is very finely disseminated. According to reliable information, the ore being mined and milled at present contains 0.8 to 1 per cent MoS_2 and a varying amount of oxidized mineral up to 0.35 per cent MoO_3. The larger part of the ore body, however, is more completely oxidized, and the economic recovery of the molybdite must be assured before this becomes available as a source of molybdenum.

Near Sweetwater, Nev., is a rich deposit of molybdenite and molybdite that has not been previously described. The main body of ore is in a nearly vertical dike of more or less decomposed granite; this dike shows a mineralized outcrop for a distance of about 3,000 feet. In 1924 the workings consisted of two tunnels that cut the vein for distances of 75 and 50 feet at elevations about 30 feet apart.

A remarkable feature of this deposit is the extent to which the molybdenite has been altered to molybdite. This alteration probably extends to a considerable depth. The owners claim that a sample taken from a 12-foot face showed 3.62 per cent MoS_2 and 6.78 MoO_3, and that 15 tons of ore containing 15 per cent MoS_2 have been shipped from the workings.

The molybdenite occurs in masses in seams and pockets and also is disseminated in small flakes throughout the granite. The molybdite is even more thoroughly disseminated, occurring as incrustations that range from thin seams and small pockets to merely a stain. The granite has undergone considerable metamorphism, and "sugar quartz" is common.

[1] Hess, F. L., Molybdenum Deposits: U. S. Geol. Survey Bull. 761, 1924, 35 pp.

Generated on 2024-10-06 18:25 GMT / https://hdl.handle.net/2027/mdp.39015006902764
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF MICHIGAN

Both the Climax and the Sweetwater ores are exceptionally free from undesirable impurities. Ore samples obtained from these sources as material for the tests described in this paper were analyzed with the following results:

Analyses of Climax and Sweetwater ores

	Climax	Sweetwater
	Per cent	*Per cent*
Insoluble	94.5	92.8
MoS_2	.223	1.08
MoO_3	.697	.63
CaO	Trace.	1.00
Fe	2.91	.87
P	Trace.	.017

The Climax ore was a milled product containing considerable metallic iron that was introduced during grinding.

POSSIBLE METHODS OF RECOVERING MOLYBDITE

Possible methods of recovering molybdite or other oxidized and soluble forms of molybdenum have been considered, as stated below.

FLOTATION

Flotation is the only method that would not involve extensive changes in present concentrating plants and is therefore the most desirable possibility. A number of reagents were tested under a great variety of conditions and methods of procedure, and in no test was there any indication that the molybdite could be floated. Exhaustive efforts were made to sulphidize the molybdenite by the use of sodium sulphide, calcium polysulphide, barium polysulphide, and various mixtures of these. In some tests the ore was ground when mixed with the collecting oil and sulphidizing reagent, in others the reagents were added during the progress of the flotation. Neutral, acid, and alkaline solutions were used and the temperature was varied up to 40° C. The sulphidized pulp was neutralized or acidified with sulphuric acid before or during the flotation operation. The ore was ground with a fused mixture of sodium sulphide, sulphur, and paraffin. The pulp was treated with nitroso-beta naphthol and again with cupferron in the hope of a reaction with the molybdite to form flotable tarry complexes. With all these reagents various combinations of coal tar, creosote, and pine oils were used; also T. and T. mixture, X cake, and others. All the tests gave negative results, and this method was reluctantly abandoned.

GRAVITY CONCENTRATION

Because of the low specific gravity and softness of molybdite, obviously none of the usual gravity methods can be successful.

Generated on 2024-10-06 18:24 GMT / https://hdl.handle.net/2027/mdp.39015006902764
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF MICHIGAN

DIELECTRIC CONCENTRATION

As both molybdite and molybdenite have relatively high dielectric constants, it seems that a fairly clean separation of both minerals may be possible by the dielectric method described by Hatfield.[2] In this method a finely divided suspension of the ore in a mixture of kerosene and nitrobenzene is passed through cells containing closely spaced electrode grids which are energized by a single-phase alternating current of about 200 volts and a frequency of more than 100. The metallic minerals, because they have a higher dielectric constant than that of the liquid, are attracted and held by the electrodes, while the gangue is repelled and passes through the cell. After the minerals are washed free of gangue, the current is switched off and the concentrate is flushed out of the cell. The organic liquid is recovered from both concentrate and tailings by filtration and distillation from the filter cake.

A preliminary investigation of this method has been made at the Rare and Precious Metals station of the Bureau of Mines with a view to improving the operating conditions described by Hatfield.

Equipment was developed employing continuous operation by means of a revolving drum, similar in its operation to a magnetic pulley. The following result is typical of those obtained by this method: Ore, total Mo, 1.09 per cent (0.42 per cent as MoO_3); recovery, 82 per cent in a concentrate containing 7.6 per cent Mo. Even repeated treatments failed to give a satisfactory recovery of a commercial grade concentrate.

The factors that seem to limit the possibilities of this method are: (1) The maximum attractive force that can be exerted on a particle by dielectric stress is very feeble, several thousandfold less than that used in ordinary magnetic separation. (2) Only over a very short distance (1 mm.) and with small particles (—100 mesh) do these dieletric forces overcome the pull of gravity and convection currents, nor are they able to separate particles of gangue that adhere to the mineral grains. (3) The cost of recovering the liquid medium and the value of the unrecovered liquid medium.

At its present stage of development this method does not compare favorably with other methods.

LEACHING

Molybdite is readily soluble in dilute mineral acids and in caustic or soda solutions. Ammonia is ineffective as a solvent. The conditions required to extract the soluble molybdenum from the insoluble constituents of the ore and the various methods of recov-

[2] Hatfield, H. S., Dielectric Concentration: Inst. Min. and Met. Bull. 233, February, 1924, 8 pp.

Generated on 2024-10-06 18:22 GMT / https://hdl.handle.net/2027/mdp.39015006902764
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF MICHIGAN

ering marketable molybdenum products from the solutions thus obtained were investigated carefully. The molybdenite may be recovered separately by flotation, or it may be first oxidized by roasting the ore and then extracted with the molybdite.

From a series of tests in which various proportions of ore, water, and reagents were digested at various temperatures and durations of time, the following data were selected as best representing commercial requirements. In each test the MoS_2 content of the ore was ignored, extraction being based upon the oxidized or soluble content.

Leaching tests

Ore, grams	Water, grams	Reagent	Grams	Temperature, ° C.	Extraction, per cent
2,000	1,500	Soda	100	90	88
		60° H_2SO_4	140	40	93
		18° HCl	170	40	93

Extraction by the acid leach requires moderate heat and falls short of 100 per cent only through incomplete washing or insufficient acidity. In the soda leach a higher temperature is necessary to decompose or prevent the formation of insoluble molybdates. These molybdates also precipitate in the residue when it is being washed unless the wash water is kept decidedly alkaline. At 40° C. the soda leach gave an extraction of 80 per cent with the Climax ore, but practically none with the Sweetwater ore. The two ores gave practically identical results in the tests noted above.

Out of many different methods tested for recovering molybdenum from these solutions, one each for the acid and soda leach were selected as best meeting commercial needs. In both the leaching operation consisted of digesting 2,000 grams of ore with the stated quantity of reagent and 1,000 grams of water, filtering, and then washing with 500 to 1,000 grams of water.

Figure 1 represents diagrammatically a process for recovering a pure molybdic acid from the sodium carbonate leach. Step *1* is merely the leaching operation. At *2* the solution is made just acid with sulphuric, then sodium acetate and lead sulphate are added. Digestion at 40° C. converts the lead sulphate to lead molybdate, precipitating the molybdenum completely. Leaching and digestion eliminate the main bulk of impurities, and subsequent operations involve only small quantities of materials. At *3* the lead molybdate is decomposed by sulphuric acid, forming a molybdic acid solution and lead sulphate; the latter, with any undecomposed molybdate, is returned to step *2*. In *4* the phosphorus is precipitated and removed

Generated on 2024-10-06 18:16 GMT / https://hdl.handle.net/2027/mdp.39015006902764
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF MICHIGAN

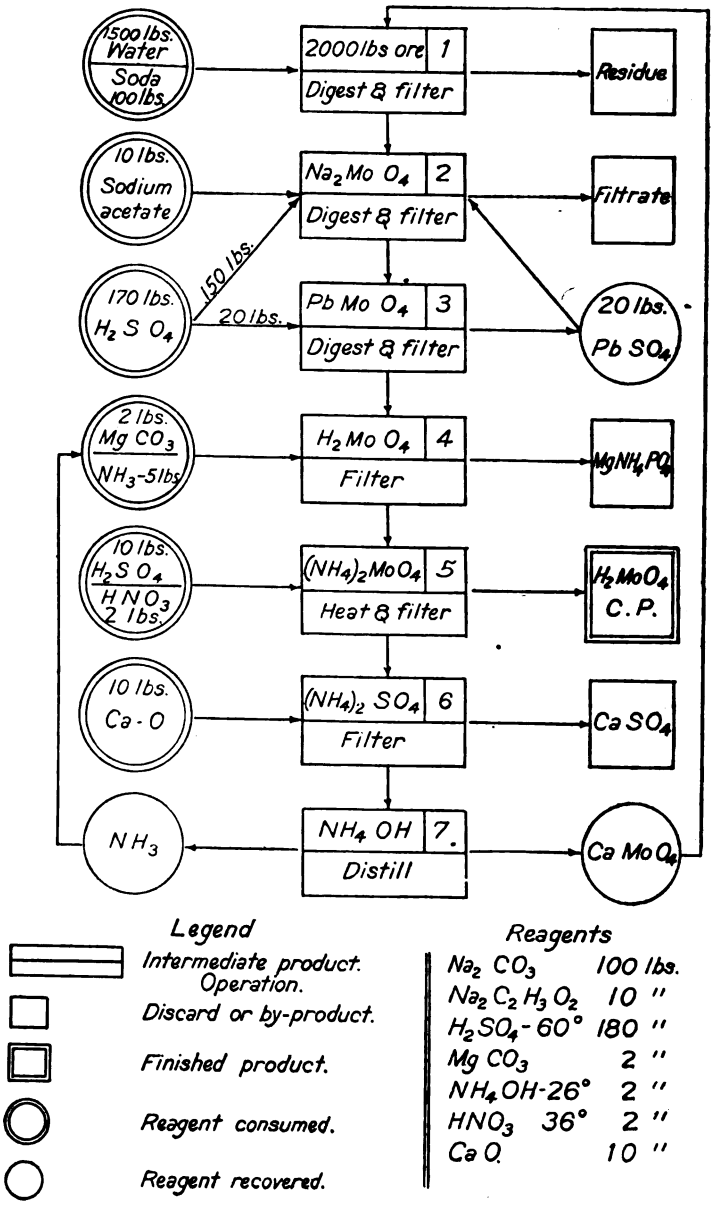

FIGURE 1.—Diagram of a process for recovering a pure molybdic acid from a sodium carbonate leach

Generated on 2024-10-06 18:22 GMT / https://hdl.handle.net/2027/mdp.39015006902764
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF MICHIGAN

as magnesium ammonium phosphate, the filtrate of ammonium molybdate being decomposed at *5* with sulphuric and nitric acids. Moderate heat precipitates the bulk of the molybdenum as C. P. molybdic acid. The filtrate from *5* is treated with an excess of hydrated lime at *6* and quickly filtered. A little molybdenum is lost in the precitate of calcium sulphate, but most of it goes with the filtrate to *7* where it precipitates as $CaMoO_4$, then the ammonia is distilled off and may be returned to step *1* or otherwise utilized.

The process involves six filtrations, only one of which has a bulky residue and only two have a large amount of solution. Not more than a ton of solution should be required for a ton of ore. None of the precipitates are difficult to filter. If the amount of arsenic, phosphorus, and other impurities is not too large, molybdic acid may be recovered directly from solution at step *4*.

Figure 2 represents a process starting with a sulphuric acid leach. At step *2* the warm solution (40° C.) is agitated about 16 hours with a large excess of scrap iron until the molybdenum is completely reduced to the quadrivalent or lower condition and the free acid is entirely neutralized. Under these conditions the molybdenum is quantitatively precipitated, probably as a hydrate of MO_2. This precipitate when filtered, washed, and dried contains over 50 per cent Mo, a small but variable amount of iron, and traces of other impurities, including any phosphorus originally present. This procedure should not be confused with the well-known method of precipitating an iron molybdate from an oxidized solution. The lower oxides of molybdenum are basic and do not react with iron or other bases. The iron found in the precipitate is partly insoluble salts, such as the phosphate, and partly ferrous sulphate which has not been completely removed by washing. In one test the roasted products contained 85.8 per cent MoO_3 and 13.9 per cent Fe_2O_3.

The possibility of using this product for direct addition to steel is worth consideration. The molybdenum is present as a lower oxide, which is not volatile at the temperature maintained in a steel furnace. If calcium molybdate is found to be preferable, it may be produced by mixing the roasted precipitate with freshly slaked lime.

Phosphorus and arsenic are common constituents of molybdenite ores, and usually a large part of these impurities will be found in the MoO_2 precipitate. Although the proportion of such impurities in the Climax ore is so small that further purification does not seem necessary, many other ores carry phosphorus that must be eliminated, as indicated in the flow sheet, steps *3* to *6*. The precipitate is roasted and leached with ammonia at steps *3* and *4*. At step *5* phosphorus is precipitated with $MgCl_2$. Either calcium molybdate or molybdic acid may be precipitated in a very pure state at step *6*.

Generated on 2024-10-06 18:22 GMT / https://hdl.handle.net/2027/mdp.39015006902764
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF MICHIGAN

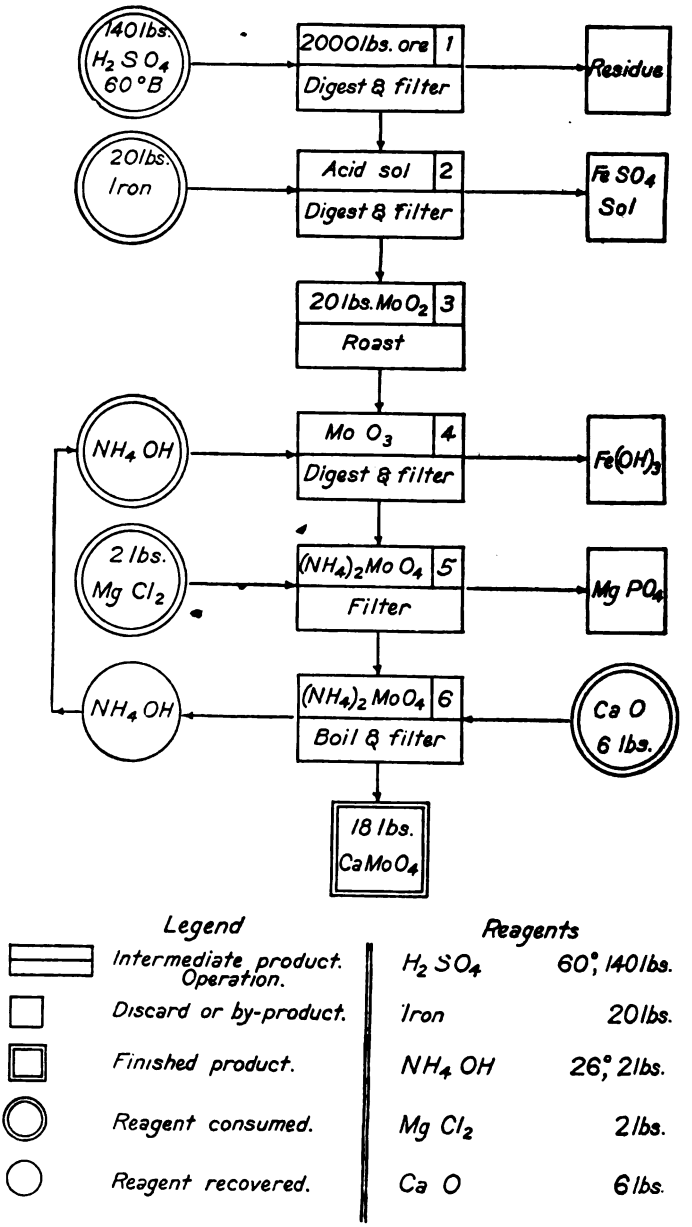

FIGURE 2.—Diagram of a process for recovering a pure molybdic acid from a sulphuric acid leach

Generated on 2024-10-06 18:25 GMT / https://hdl.handle.net/2027/mdp.39015006902764
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF MICHIGAN

At first glance these flow sheets may seem to involve rather a large number of expensive operations. The reader should note, however, that in either process step *2* eliminates all material except a dense product having about 1 per cent of the weight of the ore treated. The remaining operations are scarcely more than laboratory procedure and should not be expensive. No large bulk of solution need be heated above the temperature required to extract the molybdenum from the ore.

As the cost of mining and milling may be charged against the recovery of the sulphide content of the ore, only the steps indicated in the flow sheets enter into the cost of recovering the oxidized content. With ore of the grade under consideration, the cost of either of these processes, but especially of the latter, seems to compare favorably with costs of present methods of recovering the molybdenite.

The behavior of lime as a precipitant of molybdenum in the presence of sodium salts is of interest. For example, one might desire to precipitate calcium molybdate from solution *2*, process I. The excess of lime required to precipitate the molybdenum reacts with the sodium sulphate present, as follows:

$$Ca(OH)_2+Na_2SO_4 \rightleftarrows CaSO_4+2NaOH \qquad (A)$$

Free caustic soda resulting from this equilibrium holds a portion of the molybdenum in solution, and only a partial precipitation is obtained.

If solution *2* be first acidified with hydrochloric acid instead of sulphuric, then an excess of lime will give complete precipitation of molybdenum because the great solubility of calcium chloride in comparison with calcium hydrate forces the equilibrium in the opposite direction, thus:

$$CaCl_2+2NaOH \rightleftarrows Ca(OH)_2+2NaCl \qquad (B)$$

Elimination of steps *3* to *7*, inclusive, by this procedure would hardly compensate for the greater cost of the hydrochloric acid and the relatively impure quality of the final product.

Conversely, in process II, if the acid of solution *2* is neutralized by lime, caustic soda will not extract all the molybdenum from the precipitate until sufficient has been added to complete reaction B. In other words, the lime is ineffective, and an excess of caustic over that required to neutralize the original acid content must be used in order to separate the molybdenum from those constituents of the solution insoluble in an alkaline reagent. The precipitate obtained by neutralizing the acid solution is too impure to be a commercial product.

Generated on 2024-10-06 18:27 GMT / https://hdl.handle.net/2027/mdp.39015006902764
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF MICHIGAN

These reactions with lime are frequently responsible for errors in the analytical determination of both molybdenum and vanadium. Precipitations of the iron group with excess soda rather than ammonia is necessary if much lime is present.

DISTILLATION WITH CHLORINE

At about 450° C. dry chlorine gas reacts with either MoS_2 or MoO_3 to form $MoCl_5$ and $Mo_2O_3Cl_5$, respectively. These compounds are readily distilled from an ore with virtually all the molybdenum recovered. When $MoCl_5$ is formed, S_2Cl_2 is also a product of the reaction and the stoichiometric ratio of Cl_2 to Mo is 2.6. In the reaction with MoO_3 this ratio is about 0.92.

In the recovery of molybdenum from an ore containing MoS_2 it is obviously advantageous, as far as the consumption of chlorine is

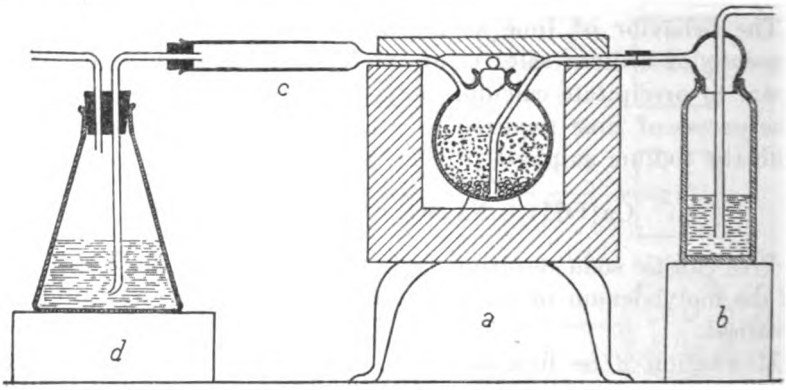

FIGURE 3.—Apparatus used in laboratory tests

concerned, first to oxidize the sulphides by roasting. There are, however, even greater advantages in a preliminary roast. Iron sulphides and metallic iron (introduced into the ore during grinding) react with chlorine, distill, and contaminate the molybdenum product, whereas iron oxide under the same conditions is practically unaffected. Also, on a large scale $Mo_2O_3Cl_5$ can be distilled from the hot, roasted ore without application of external heat, a fact that greatly simplifies the problem of providing satisfactory equipment for distilling.

The apparatus shown in Figure 3 was adopted for laboratory tests of this method. The reaction chamber *a* consists of a 300-c.c. spherical pyrex flask with inlet and outlet tubes sealed in, as shown. The neck of the flask is cut short and is closed by a glass stopper; a cement of barium sulphate and water glass is used to seal the joint. Two hundred grams of roasted ore are charged in the flask on top of a layer of small pebbles which help to distribute the chlorine

Generated on 2024-10-06 18:18 GMT / https://hdl.handle.net/2027/mdp.39015006902764
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF MICHIGAN

throughout the ore. After the neck is sealed the flask is placed in a Hoskins electric furnace and heated to about 500° C. for about two hours.

A measured flow of chlorine gas is then drawn through the ore, first passing through the wash bottle *b*, containing concentrated sulphuric acid. The distillate of molybdenum oxychloride collects in the condenser *c* and the excess chlorine is adsorbed in the wash bottle *d*, which contains warm sodium hydroxide solution. The whole system is kept slightly below atmospheric pressure by means of a suction pump connected to *d*.

Moisture collecting in the condenser is driven off by heating the tube, previous to the distillation. During the distillation the small tube connecting the condenser and the reaction chamber is kept free of distillate by heating with a Bunsen burner. Chlorine is passed through at a rate of from 10 to 30 c.c. per minute for a period of 30 to 90 minutes. The total quantity of chlorine thus estimated is later checked by an analysis of all the products. The following results were obtained with 200-gram samples of roasted ore containing 0.61 per cent Mo. This was a milled product from Climax, Colo.

Results of tests of Climax ore

Test	8	10	13	3	12
Mo in distillate (*c*)....per cent..	Total	Total	Total	91	79
Cl in residue (*a*)....grams..	0.04	0.04	0.04	.....	.05
Cl in distillate (*c*)....do....	.69	.73	.72	.....	.54
Cl in wash (*d*)....do....	2.56	1.55	1.28	.....	.93
Cl used per pound Mo....pounds..	2.74	1.93	1.70	1.45	1.27
Cl consumed per pound Mo....do....	.61	.64	.63	.....	.50

Unavoidable variations in the conditions of distillation affect the appearance and probably the composition of the distillate. The distillate in the hotter part of the condenser is a compact scale, but the remainder is usually "woolly." This difference may account for the variations in the Cl-Mo ratio of the distillate, but mostly the variations are attributed to the fact that molybdenum oxychloride is very unstable in the presence of moisture, and loss of chlorine may occur during distillation or when the distillate is removed from the condenser. In all cases the Cl-Mo ratio of the distillate is less than theoretical, and therefore is of little significance.

The distillate reacts vigorously with water to form MoO_3, Cl_2, and HCl. Since dry HCl also reacts with MoO_3 to form a volatile hydrochloride, it seems probable that by introducing the proper amount of steam into the condenser virtually all the chlorine can be regenerated in a form suitable for further use. For example, a plant could be designed to feed the hot roasted ore into a retort in

Generated on 2024-10-06 18:19 GMT / https://hdl.handle.net/2027/mdp.39015006902764
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF MICHIGAN

which the ore and gases travel countercurrent—as in a blast furnace, but on a smaller scale. The chlorine would be fed through tuyères near the bottom and the distillate drawn off at the top to a hot condenser, where just enough steam is admitted to decompose the molybdenum oxychloride. The blower used to remove the uncondensed gases would return the excess and regenerated chlorine and hydrochloride through a calcium chloride drying chamber and thence to the retort.

Even if the regeneration of the chlorine should not prove feasible, there is little doubt that by continuous countercurrent reaction the consumption of chlorine need be little more than that required to react with the ore. It may be stated, then, that with Climax ore the consumption of chlorine for each pound of molybdenum recovered will be not more than 2 pounds, probably little more than 1 pound, and possibly, by regeneration of the chlorine, much less. This process requires only a short roast at 500 to 600° C., and the roasting may be done with direct heat in the most efficient type of furnace. Complete oxidation of the ore, although desirable, is not essential. Application of heat during the distillation is not necessary in large-scale operation.

It is recognized that the handling of chlorine on a large scale presents difficulties. These may be compensated by the following advantages of the method: (1) Practically complete separation of the molybdenum from all other ore constituents is accomplished in one simple operation. In all other methods the recovery is incomplete, and the MoS_2 and MoO_3 are extracted by separate operations; the products are not as desirable and must be refined by different methods. (2) The product is easily and cheaply converted to $CaMoO_4$ or MoO_3. (3) Fine grinding to free the mineral grains is not only unnecessary but undesirable. All that is necessary is to expose the molybdenum content of the ore to the action of the chlorine. (4) Any valuable metallic content of the ore, such as lead, copper, or gold, will be converted to a soluble form and can be extracted by leaching.

SUMMARY

Many molybdenite deposits contain a considerable amount of oxidized molybdenum. Recovery of this oxidized content is an urgent, unsolved problem.

No mechanical methods of concentration have been effective in extracting the oxidized molybdenum.

Dielectric separation is an undeveloped method which seems to have very limited possibilities.

Two leaching methods have been carefully tested and seem to have commercial possibilities: (1) Extract the ore with hot soda

Generated on 2024-10-06 18:16 GMT / https://hdl.handle.net/2027/mdp.39015006902764
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF MICHIGAN

solution, acidify with sulphuric acid, add a small amount of sodium acetate, and digest with lead sulphate. Molybdenum is completely precipitated as $PbMoO_4$, which can be converted to MoO_3. (2) Extract the ore with warm, dilute sulphuric acid and completely neutralize the free acid with scrap iron. Molybdenum is completely precipitated as a hydrate of MoO_2, nearly pure.

By treating the hot roasted ore with chlorine practically complete separation of the molybdenum from all other ore constituents is obtained in one operation. The distillate is quite pure and is easily converted to MoO_3 or $CaMoO_4$. The consumption of chlorine need not be heavy and the regeneration of chlorine for repeated use seems possible.

Generated on 2024-10-06 18:19 GMT / https://hdl.handle.net/2027/mdp.39015006902764
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from UNIVERSITY OF MICHIGAN